Comparative Seismic Analysis of RCC, Steel & Steel-Concrete Composite Frame

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS OF THE DEGREE FOR THE DEGREE OF

Bachelor of Technology

in

Civil Engineering

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Rourkela

Certificate

This is to certify that the project entitled — "**Comparative Seismic Analysis of RCC, Steel & Steel-Concrete Composite Frame"** submitted by **Mr. Rahul Pandey** [Roll No. 110CE0469] in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Civil Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge the matter embodied in the project has not been submitted to any other university/institute for the award of any degree or diploma.

Date: 12th May 2014

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Rahul Pandey

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ABSTRACT

Steel-Concrete composite constructions are nowadays very popular owing to their advantages over conventional Concrete and Steel constructions. Concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instruct more deflections and ductility to the structure, which is beneficial in resisting earthquake forces. Composite Construction combines the better properties of both steel and concrete along with lesser cost, speedy construction, fire protection etc. Hence the aim of the present study is to compare seismic performance of a 3D (G+7) storey RCC, Steel and Composite building frame situated in earthquake zone V. All frames are designed for same gravity loadings. The RCC slab is used in all three cases. Beam and column sections are made of either RCC, Steel or Steel-concrete composite sections. Equivalent static method and Response Spectrum method are used for seismic analysis. SAP 2000 software is used and results are compared. Cost effectiveness based on material cost for all types of building frames is determined.

Comparative study concludes that the composite frames are best suited among all the three types of constructions in terms of material cost benefit added with better seismic behavior.

CHAPTER-1

Introduction

1.1 BACKGROUND

In India most of the building structures fall under the category of low rise buildings. So, for these structures reinforced concrete members are used widely because the construction becomes quite convenient and economical in nature. But since the population in cities is growing exponentially and the land is limited, there is a need of vertical growth of buildings in these cities. So, for the fulfillment of this purpose a large number of medium to high rise buildings are coming up these days. For these high rise buildings it has been found out that use of composite members in construction is more effective and economic than using reinforced concrete members. The popularity of steel-concrete composite construction in cities can be owed to its advantage over the conventional reinforced concrete construction. Reinforced concretes frames are used in low rise buildings because loading is nominal. But in medium and high rise buildings, the conventional reinforced concrete construction cannot be adopted as there is increased dead load along with span restrictions, less stiffness and framework which is quite vulnerable to hazards.

In construction industry in India use of steel is very less as compared to other developing nations like China, Brazil etc. Seeing the development in India, there is a dire need to explore more in the field of construction and devise new improved techniques to use Steel as a construction material wherever it is economical to use it. Steel concrete composite frames use more steel and prove to be an economic approach to solving the problems faced in medium to high rise building structures.

1.1.a Composite Structures

When a steel component, like an I-section beam, is attached to a concrete component such that there is a transfer of forces and moments between them, such as a bridge or a floor slab, then a composite member is formed. In such a composite T-beam, as shown in Figure 1.1, the comparatively high strength of the concrete in compression complements the high strength of the steel in tension. Here it is very important to note that both the materials are used to fullest of their capabilities and give an efficient and economical construction which is an added advantage.

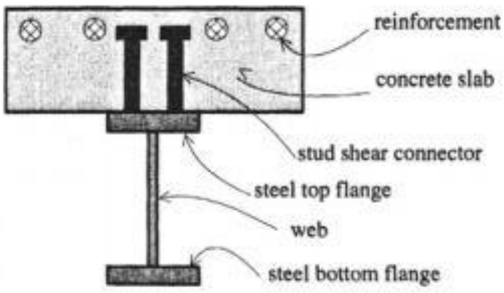


Figure 1.1 Cross Section of a typical composite member

- **Composite Steel-Concrete beam:-** A concrete beam is formed when a concrete slab which is casted in-situ conditions is placed over an I-section or steel beam. Under the influence of loading both these elements tend to behave in an independent way and there is a relative slippage between them. If there is a proper connection such that there is no relative slip between them, then an I-section steel beam with a concrete slab will behave like a monolithic beam. The figure is shown in the figure 1.2. In our present study, the beam is composite of concrete and steel and behaves like a monolithic beam. Concrete is very weak in tension and relatively stronger in tension whereas steel is prone to buckling under the influence of compression. Hence, both of them are provided in a composite such they use their attributes to their maximum advantage. A composite beam can also be made by making connections between a steel I-section with a precast reinforced concrete slab. Keeping the load and the span of the beam constant, we get a more economic cross section for the composite beam than for the non-composite tradition beam. Composite beams have lesser values of deflection than the steel beams owing to its larger value of stiffness. Moreover, steel beam sections are also used in buildings prone to fire as they increase resistance to fire and corrosion.

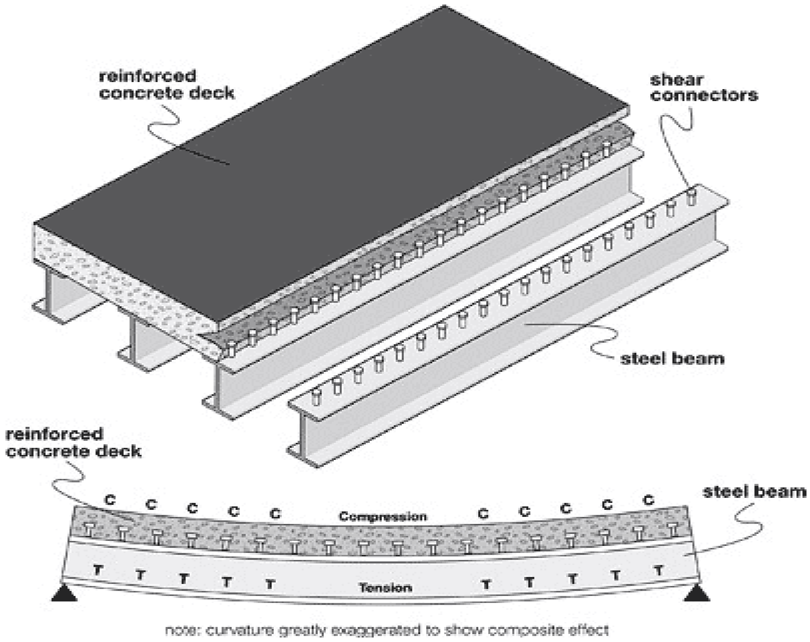


Figure 1.2 Composite beam

- **Steel-Concrete Composite Columns:-** A steel-concrete composite column is a compression member comprising of a concrete filled tubular section of hot-rolled steel or a concrete encased hot-rolled steel section. Figure 1.3(a) and figure 1.3(b) show concrete filled and concrete encased column sections respectively. In a composite column, both the concrete and the steel interact together by friction and bond. Therefore, they resist external loading. Generally, in the composite construction, the initial construction loads are beared and supported by bare steel columns. Concrete is filled on later inside the tubular steel sections or is later casted around the I section. The combination of both steel and concrete is in such a way that both of the materials use their attributes in the most effective way. Due to the lighter weight and higher strength of steel, smaller and lighter foundations can be used. The concrete which is casted around the steel sections at later stages in construction helps in limiting away the lateral deflections, sway and bucking of the column. It is very convenient and efficient to erect very high rise buildings if we use steel-concrete composite frames along with composite decks and beams. The time taken for erection is also less due to which speedy construction is achieved along better results.

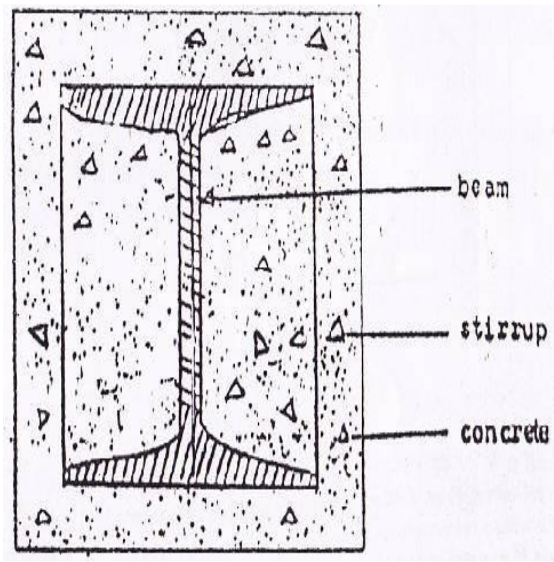


Figure 1.3.a Concrete encased steel column

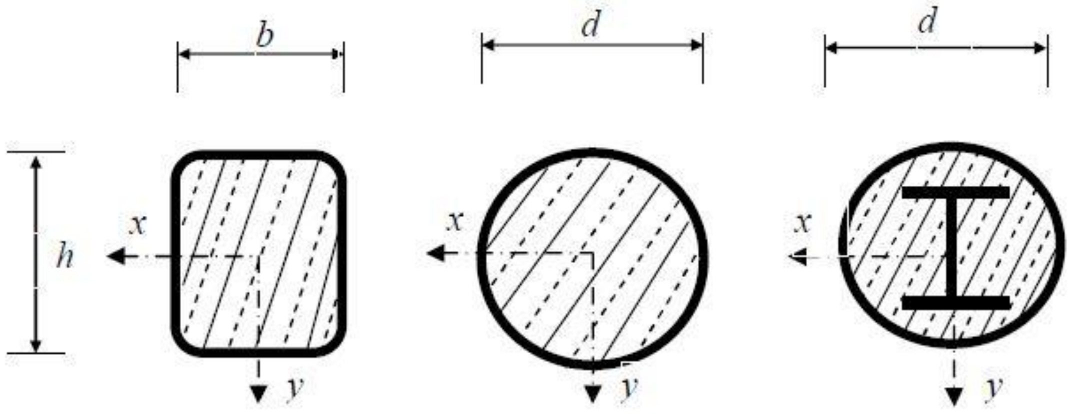


Figure 1.3.b Steel encased concrete column sections

1.2 LITERATURE REVIEW

D.R. Panchal & **Dr. S.C. Patodi** evaluated the seismic performance of multistoried building for which they have considered Steel-Concrete Composite and R.C.C. For their analysis the methods that they used were Equivalent static method and Linear Dynamic Response Spectrum Analysis. The results thus obtained were analyzed and compared with each other .

Jingbo Liu, Yangbing Liu, Heng Liu proposed a performance based fragility analysis based method in which the uncertainty due to variability in ground motion and structures are considered. By the proposed method of fragility analysis they performed analysis of a 15 storeyed building having composite beam and concrete filled square steel tube column.

G.E. Thermou, A.S. Elnashai, A. Plumier, C. Doneux have discussed clauses and deficiencies of the Eurocode which earlier used to cause problem for the designers. For obtaining the response of the frames, methods of pushover analysis were also employed. Their main purpose was to study and investigate if the designed structure could behave in an elastically dissipative way.

Shashikala. Koppad, Dr. S.V.Itti considered steel-concrete composite with RCC options for analyzing a B+G+15 building which is situated in earthquake zone III and earthquake loading is as per the guidelines of IS1893(part-I): 2002. The parameters like bending moment and maximum shear force were coming more for RCC structure than the composite structure. Their work suggested that composite framed structures have many benefits over the traditional RC structures for high rise buildings.

D.R. Panchal and P.M. Marathe used a comparative method of study for RCC, Composite and steel options in a G+30 storey commercial building situated in earthquake Zone IV. For this they used Equivalent static method and used the software ETABS. The comparative study included size, deflections, material consumption of members in RCC and steel sections as compared to Composite sections was also studied closely and based on this study a cost comparison analysis was also performed.

A.S. Elnashai and A.Y. Elghazouli developed a model for analysis of structures subjected to cyclic and dynamic loads. These structures were primarily Steel-Concrete Composites and the model they developed was a non-linear model. The efficiency and accuracy of the developed model is shown through correlation between the experimental results and analytical simulations. The model was used for parametric studies resulting in providing important conclusion for ductility based earthquake-resistant design.

1.3 Aim of the present study:

The aim of the present study is to compare performance of a 3D (G+7) story RCC, Steel and composite building frame situated in earthquake zone V. All frames are designed for same gravity loadings. The RCC slab is used in all three cases. Beam and column sections are made of either RCC, Steel or Steel-concrete composite sections. Equivalent static method and Response Spectrum method are used for seismic analysis. SAP 2000 software is used and results are compared. Cost effectiveness based on quantity of materials of all types are determined.

1.4 Problem Statement:

Eight storey (G+7) building frame with three bays in horizontal and three bays in lateral direction is analyzed by Equivalent Static Method and Response Spectrum Method.

The geometrical parameters of the building are as follows:

- Height of each storey = 3.5 m
- Center-to-center span between each column along X and Y direction = 5 m
- Fixed type support at the bottom.

The loads on the building are as follows:

- Dead Load:-
  1. Self weight of the frame
  2. Dead load of floors
     a. Dead floor load of all the intermediate floors = 6.8 KN/m^2
     b. Dead load of the roof floor = 5.5 KN/m^2
  3. Dead load of walls
     a. On outer beams = 12 KN/m^2
     b. On inner beams = 6KN/m^2
- Live load

a. Live load on all the intermediate floors = 4KN/m^2

b. Live load on roof floor = 1.5 KN/m^2

- Earthquake load in X-direction & Y-direction as specified in IS 1893: 2002.

The seismic parameters of the building site are as follows:

- Seismic Zone: V
- Zone factor 'Z' : 0.36
- Soil type= Type II (Medium Soil)
- Building Frame System: Moment resisting RC frame.
- Response Reduction Factor = 5
- Importance factor = 1
- Fundamental natural time period, T= 0.075 $H^{0.75}$ (moment-resisting frame building without brick in the panels).

  Since H= 28 m , hence T= 0.9169 sec along both directions.

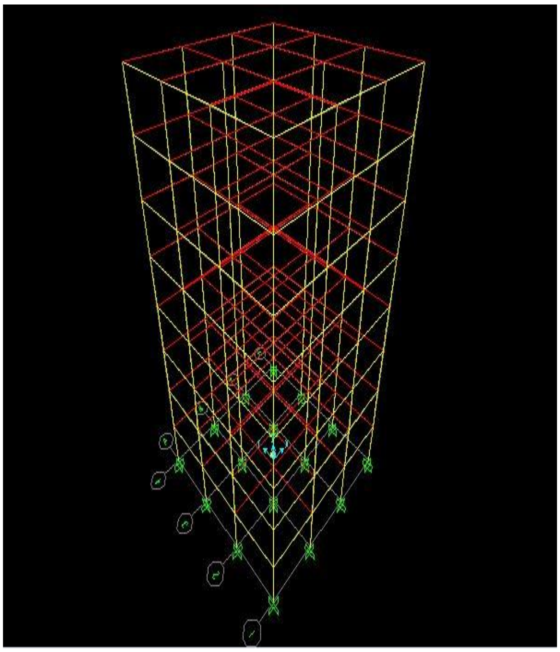


Figure 1.4.a 3-D model of the frame structure

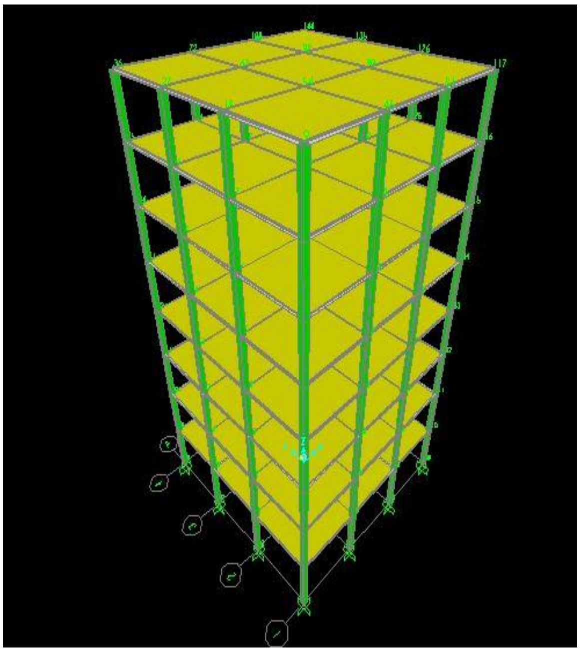


Figure 1.4.b 3-D filled model of the frame structure

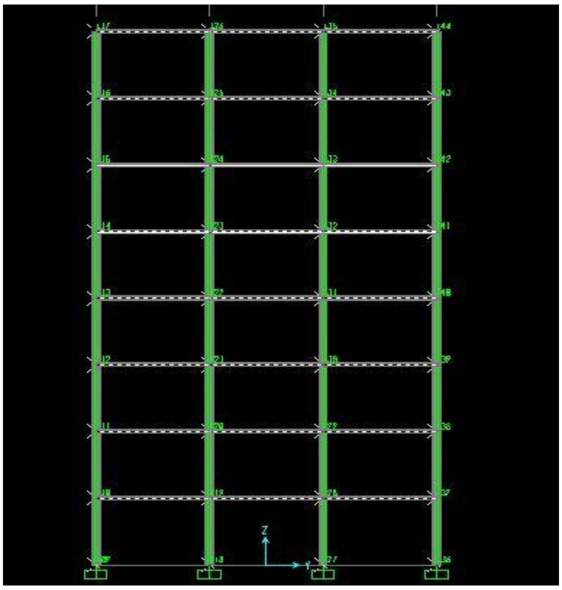


Figure 1.4.c 2-D(y-z plane) model of the frame structure

CHAPTER-2

METHODOLOGY

2.1 Methodology

Step1:

Design of beam and column sections

The frame is analyzed with dead and live loads for RCC sections for beams and columns in SAP 2000.

The maximum forces in columns and beams are determined from output file.

The sections are designed manually for these maximum forces as RCC, Steel and Composite sections for the three types of frame separately.

The codes IS 456-2000, IS 800-2007 and AISC LRFD 1999 are used for RCC, Steel and Composite column section design. The steel beam designed for steel frame is provided in composite frame too. The RCC beam section provided is 0.3m x 0.4 m.

Step 2:

Analysis

Each type of frame is analyzed separately by using Equivalent Static Load Method and Response Spectrum Method by using SAP 2000.

The analysis is conducted for IS 1893(Part 1), 2002 specified combinations of loadings.

Step 3:

Comparison of results

The results obtained are compared in terms of base shear, story deflections, story drifts ,modal participation factor etc. and cost effectiveness with respect to material quantities are determined.

2.2 Design and analysis

The sections are designed for maximum moment.

The sections adopted for analysis are

Table 2.2 SECTIONS USED IN THE STRUCTURES

Section	RCC	Steel	Composite
Column	0.45mx 0.75m Cross section	ISHB 300 H	0.35m x0.35 m with ISHB 250 steel section
Beam Main and secondary	0.3m x 0.4m	ISMB 200 with 125 mm thick concrete slab on top without shear connectors.	ISMB 250 with 125 mm thick concrete slab on top without shear connectors.

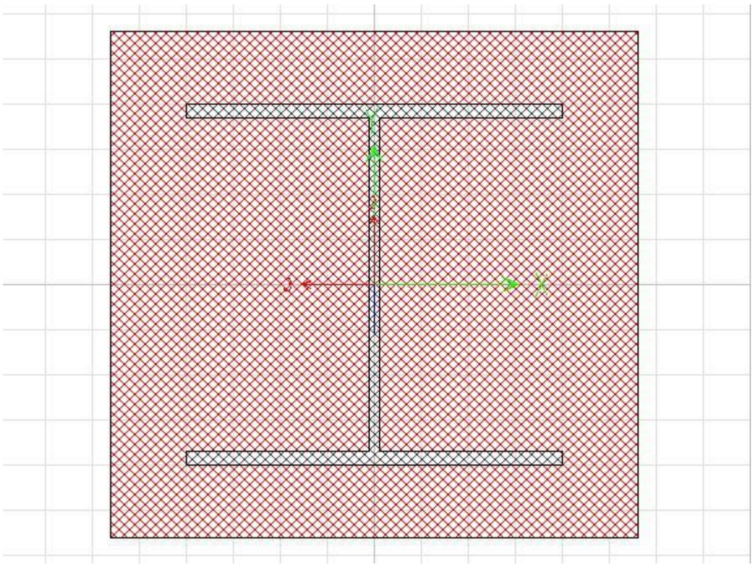


Figure 2.2.a Column Section for Composite frame

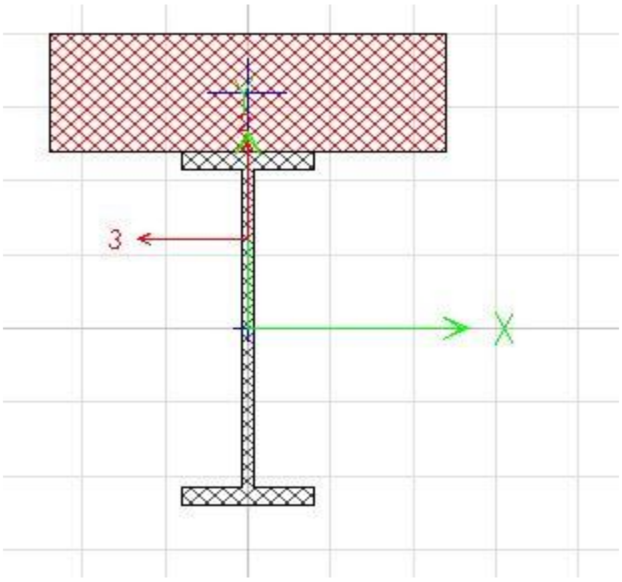


Figure 2.2.b Beam section for Composite frame and steel frame

Analysis

In the present work the two methods of analysis which have been performed are as follows.

- **Equivalent Static Analysis:**

  This method is based on the assumption that whole of the seismic mass of the structure vibrates with a single time period. The structure is assumed to be in its fundamental mode of vibration. But this method provides satisfactory results only when the structure is low rise and there is no significant twisting on ground movement. As per the IS 1893: 2002, total design seismic base shear is found by the multiplication of seismic weight of the building and the design horizontal acceleration spectrum value. This force is distributed horizontally in the proportion of mass and it should act at the vertical center of mass of the structure.

- **Response Spectrum Analysis:**

  Multiple modes of responses can be taken into account using this method of analysis. Except for very complex or simple structure, this approach is required in many building codes. The structure responds in a way that can be defined as a combination of many special modes. These modes are determined by dynamic analysis. For every mode, a response is perused from the design spectrum, in view of the modal frequency and the modal mass, and they are then combined to give an evaluation of the aggregate response of the structure. In this we need to ascertain the force magnitudes in all directions i.e. X, Y & Z and afterwards see the consequences for the building. Different methods of combination are as follows:

- Absolute-peak values are added together.
- Square root of the sum of squares(SRSS).
- Complete quadratic combination(CQC).

In our present study we have used the SRSS method to combine the modes. The consequence of a response spectrum analysis utilizing the response spectrum from a ground motion is commonly not quite the same as which might be computed from a linear dynamic analysis utilizing the actual earthquake data.

Load combinations as per IS1893- 2002 :

- 1.7(DL+LL)
- 1.7(DL+EQ)
- 1.7(DL-EQ)
- 1.3(DL+LL+EQ)
- 1.3(DL+LL-EQ)

CHAPTER-3

RESULTS AND DISCUSSION

3.1 RESULTS

Results obtained from the analysis are

1. **Equivalent Static method**

Table 3.1.1.a Storey Drift due to Equivalent Static Analysis in X-direction

Storey number	Drift of Steel in X-direction	Drift of Composite in X-direction	Drift of RCC in X-direction
0	0	0	0
1	0.228706	0.0634	0.0085
2	0.25166	0.16	0.0185
3	0.2623	0.21	0.026
4	0.2397	0.223	0.028
5	0.2016	0.219	0.032
6	0.19956	0.198	0.027
7	0.170416	0.167	0.02
8	0.132716	0.132	0.0105

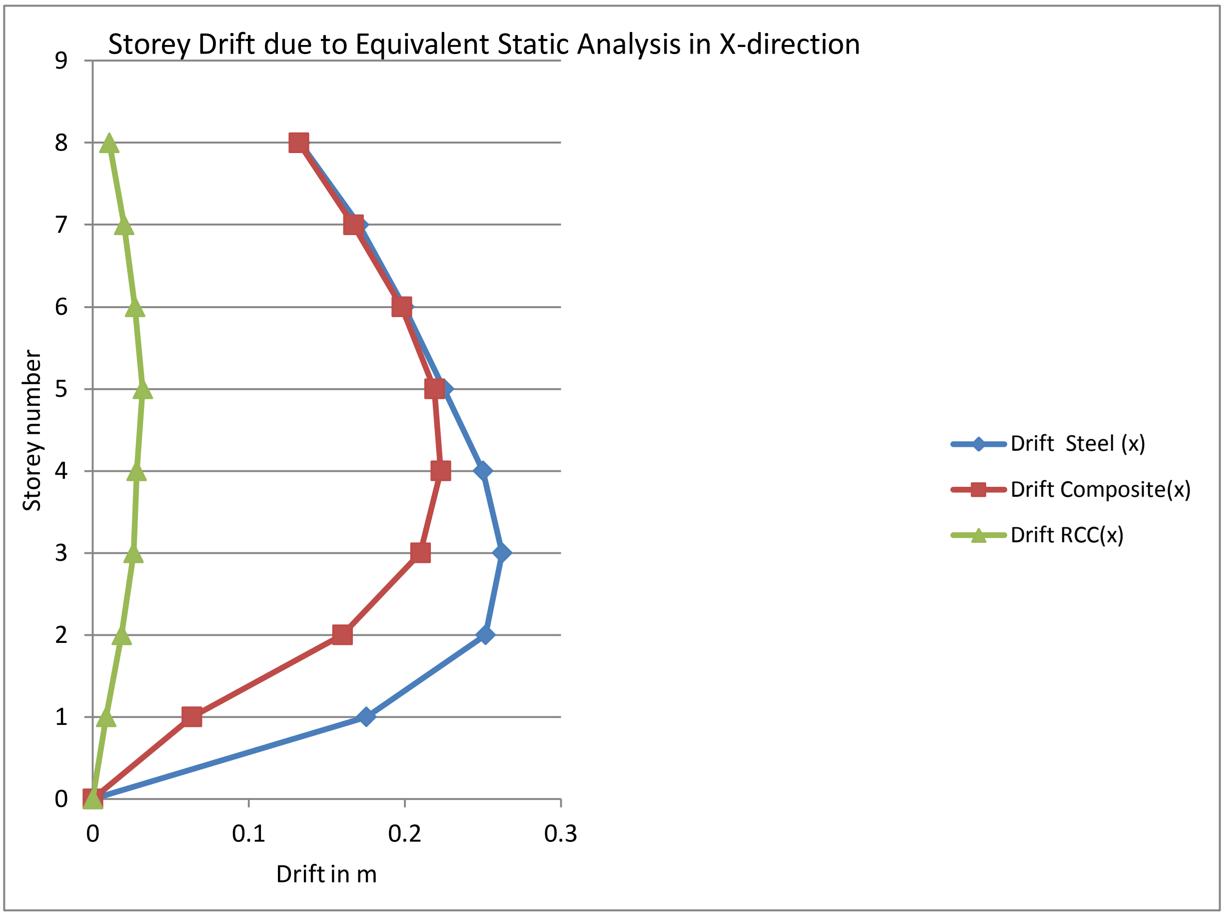


Figure 3.1.1.a Storey Drift in X-direction

It is observed that storey drift in Equivalent Static Analysis in X-direction is more for Steel frame as compared to Composite and RCC frames. RCC frame has the lowest values of storey drift because of its high stiffness.

Table 3.1.1.b Storey Drift in Equivalent Static method in Y-direction

Storey number	Drift of Steel in Y-direction	Drift of Composite in Y-direction	Drift of RCC in Y-direction
0	0	0	0
1	0.173725	0.0634	0.0085

2	0.325014	0.16	0.0185
3	0.35656	0.21	0.026
4	0.344811	0.223	0.028
5	0.308372	0.219	0.032
6	0.250333	0.198	0.027
7	0.173608	0.167	0.02
8	0.094878	0.132	0.0105

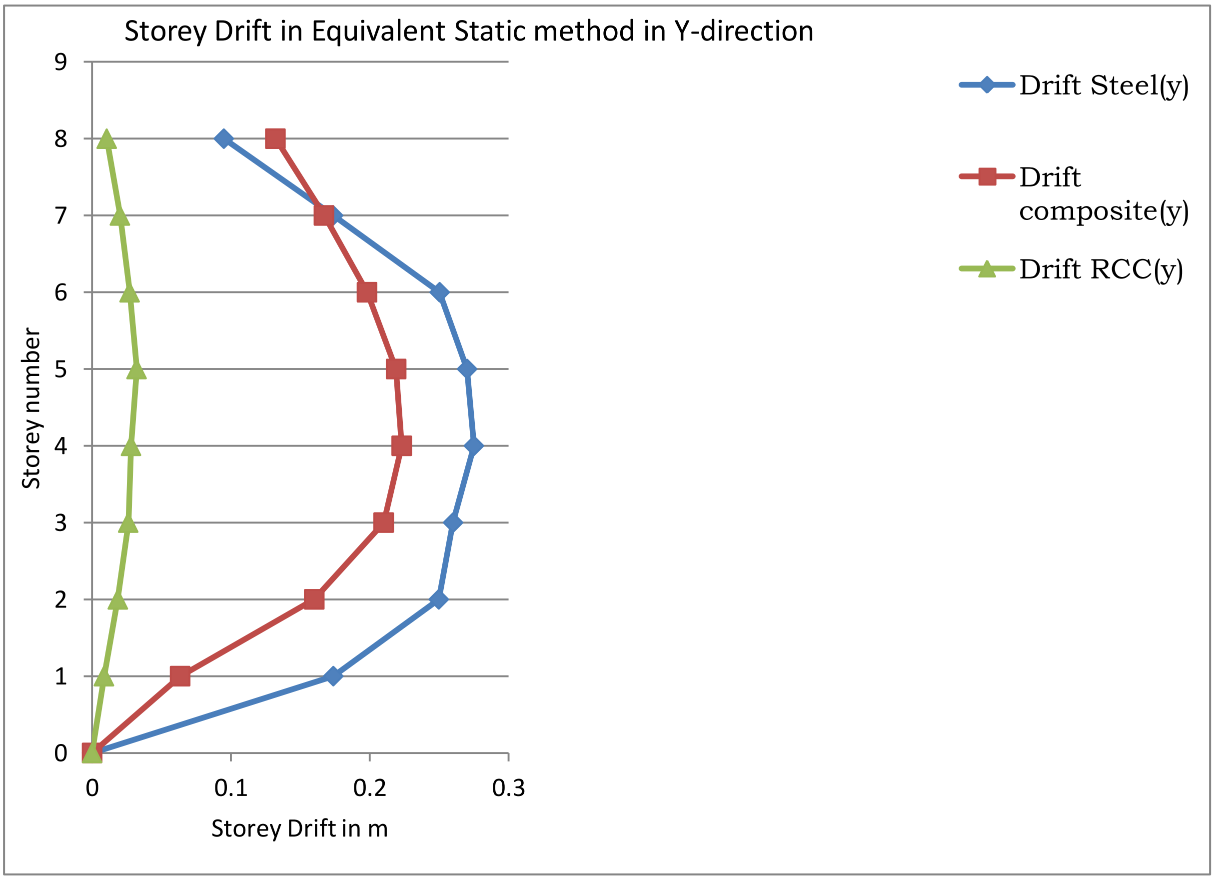


Figure 3.1.1.b Storey Drift in Y-direction

The differences in storey drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column sections are different in both directions.

2. Response Spectrum Analysis:

Table 3.1.1.c Storey Drift due to Response spectrum(X-direction)

Storey number	Drift of steel X-direction (m)	Drift of Composite in X-direction (m)	Drift of RCC in X-direction
0	0	0	0
1	0.194584	0.06183	0.00999
2	0.212933	0.14469	0.02082
3	0.24291	0.18271	0.026793
4	0.250454	0.19162	0.029301
5	0.219621	0.1818	0.024973
6	0.176447	0.16061	0.022574
7	0.128406	0.13484	0.015001
8	0.087103	0.112562	0.00792

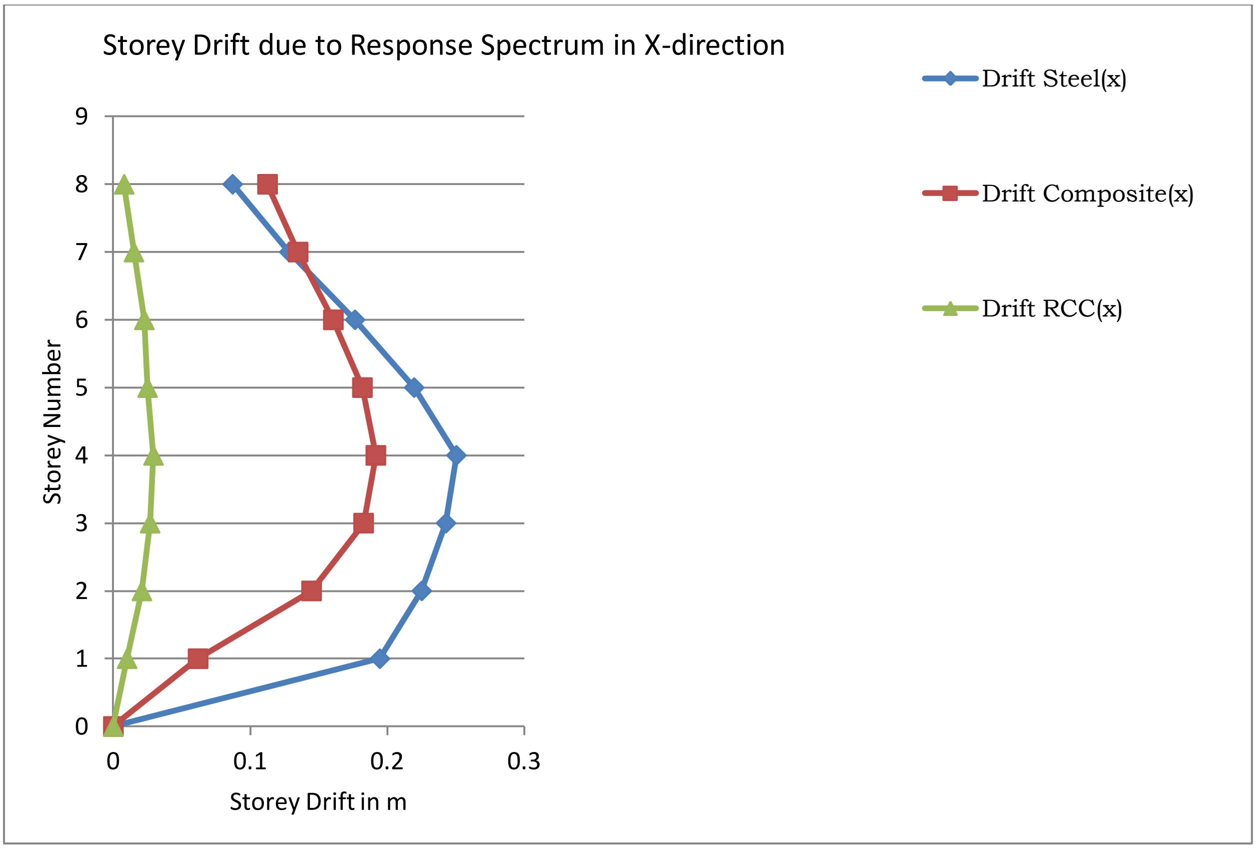


Figure 3.1.1.c Storey drift profile in X-direction

Table 3.1.1.d Storey Drift due to Response Spectrum (Y-direction)

Storey number	Drift of Steel in Y-direction (m)	Drift of Composite in Y-direction (m)	Drift of RCC in Y-direction(m)
0	0	0	0
1	0.173695	0.070635	0.016823
2	0.2251	0.1625	0.030067
3	0.25015	0.20172	0.033999
4	0.270017	0.207945	0.020062

5	0.253265	0.19353	0.022671
6	0.191607	0.16681	0.020568
7	0.124383	0.1354	0.013956
8	0.064534	0.108515	0.00736

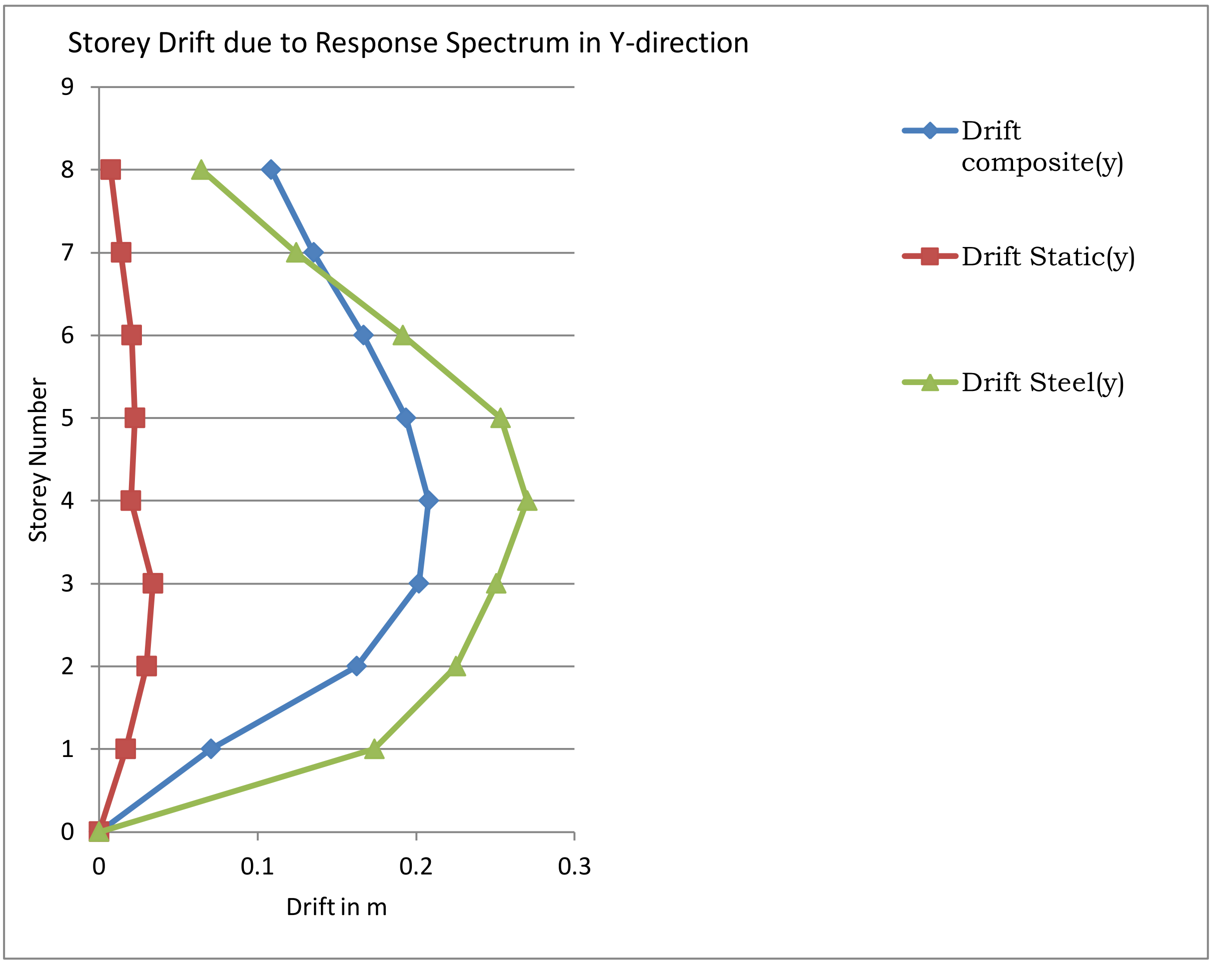


Figure 3.1.1.d Storey drift profile in Y-direction

Same storey drift patterns are obtained by using Response Spectrum method analysis validating the results obtained by the Equivalent Static method.

3.1.2. Base Shear Calculation

Table 3.1.2. Base Shear for Different Cases

	Composite	RCC	STEEL
EQx	1305.798KN	2172.7KN	1236.916KN
EQy	1305.798KN	2164.19KN	1236.92KN
RSx	1305.798KN	2179.42KN	1236.969KN
RSy	1305.798KN	2179.42KN	1236.94KN

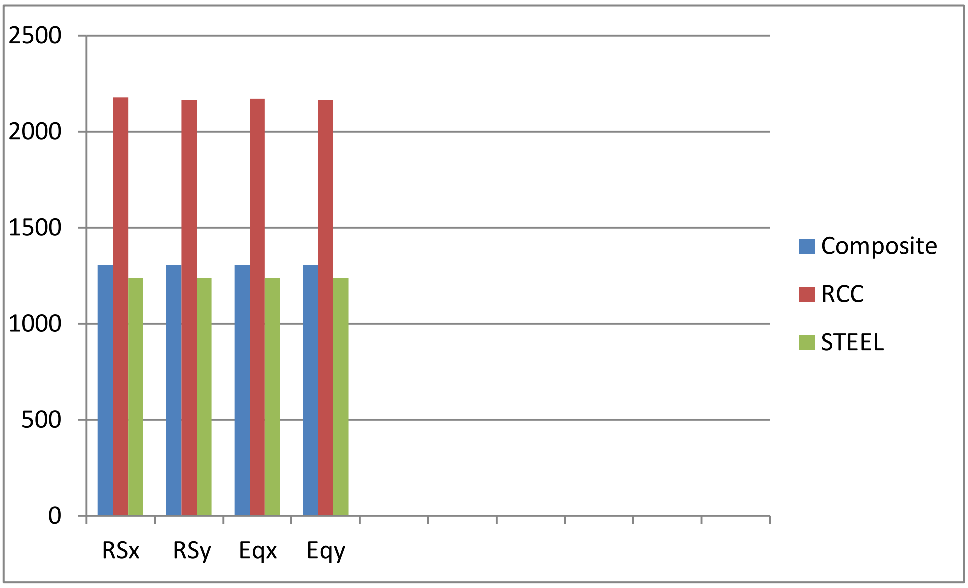


Figure 3.1.2. Base Shear for Different Cases

Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the steel and the composite frame.

3.1.3 Modal Participation factor

Table 3.1.3.a Response Spectrum (Composite)

Mode Number	Period in Seconds	Cumulative Modal participating mass in X-direction in translation	Cumulative Modal participating mass in Y-direction in translation	Cumulative Modal participating mass in X-direction in rotation	Cumulative Modal participating mass in X-direction in rotation
1	7.399237	1.25E-20	0.68549	0.84247	0
2	7.140737	0.67209	0.68549	0.84247	0.83514
3	6.304384	0.67209	0.68549	0.84247	0.83514
4	6.083174	0.67209	0.68549	0.84247	0.83514
5	5.346745	0.67209	0.74163	0.90884	0.83514
6	5.204235	0.73306	0.74163	0.90884	0.90811
7	5.06926	0.73306	0.74163	0.90884	0.90811
8	4.930562	0.73306	0.74163	0.90884	0.90811
9	2.117262	0.73306	0.82692	0.90925	0.90811
10	2.062406	0.73306	0.82692	0.90925	0.90811
11	1.99172	0.8213	0.82692	0.90925	0.909
12	1.945541	0.8213	0.82692	0.90925	0.909
13	1.683302	0.8213	0.87092	0.90946	0.909
14	1.683135	0.8213	0.87092	0.90946	0.909
15	1.58303	0.86803	0.87092	0.90946	0.90946
16	1.582915	0.86803	0.87092	0.90946	0.90946
17	0.976256	0.86803	0.90594	0.91162	0.90946
18	0.970443	0.86803	0.90594	0.91162	0.90946
19	0.894884	0.90402	0.90594	0.91162	0.91158
20	0.890398	0.90402	0.90594	0.91162	0.91158

20 modes were considered for analysis. The cumulative modal mass both in X and Y direction are approximately equal to 90%, satisfying IS 1893 specifications.

Table 3.1.3.b Response Spectrum (RCC)

Mode Number	Period in Seconds	Cumulative Modal participating mass in X-direction in translation	Cumulative Modal participating mass in Y-direction in translation	Cumulative Modal participating mass in X-direction in rotation	Cumulative Modal participating mass in Y-direction in rotation
1	2.547691	2.07E-18	0.77423	0.90591	1.06E-19
2	2.17747	0.71832	0.77423	0.90591	0.90268
3	2.052827	0.71832	0.77423	0.90591	0.90268
4	1.26328	0.71832	0.77423	0.90591	0.90268
5	0.96284	0.71832	0.77478	0.90685	0.90268
6	0.927038	0.71961	0.77478	0.90685	0.90434
7	0.842213	0.71961	0.88157	0.90773	0.90434
8	0.731998	0.71961	0.88157	0.90773	0.90434

8 modes were considered for analysis. The cumulative modal participating mass (in Y) reaches to a value of 90% of the total seismic mass. So, there is a need to increase the number of nodes so that the Cumulative modal participating mass can reach up to a sum of 90%

Table 3.1.3.c Response Spectrum (Steel)

Mode Number	Period in Seconds	Cumulative Modal participating mass in X-direction in translation	Cumulative Modal participating mass in Y-direction in translation	Cumulative Modal participating mass in X-direction in rotation	Cumulative Modal participating mass in Y-direction in rotation
1	9.280204	2.19E-18	0.74617	0.85068	1.63E-19
2	8.123352	0.69529	0.74617	0.85068	0.82725
3	7.934987	0.69529	0.74617	0.85068	0.82725
4	6.905939	0.69529	0.74617	0.85068	0.82725
5	6.552386	0.69529	0.79914	0.90858	0.82725
6	5.933679	0.76805	0.79914	0.90858	0.9106
7	5.88356	0.76805	0.79914	0.90858	0.9106
8	5.341508	0.76805	0.79914	0.90858	0.9106
9	3.060217	0.76805	0.86877	0.9102	0.9106
10	2.916718	0.76805	0.86877	0.9102	0.9106

11	2.489321	0.84353	0.86877	0.9102	0.91069
12	2.417077	0.84353	0.90181	0.91094	0.91069
13	2.413027	0.84353	0.90181	0.91094	0.91069
14	2.404411	0.84353	0.90181	0.91094	0.91069
15	1.960617	0.88305	0.90181	0.91094	0.91073
16	1.957717	0.88305	0.90181	0.91094	0.91073
17	1.67432	0.88305	0.92888	0.91317	0.91073
18	1.647212	0.88305	0.92888	0.91317	0.91073
19	1.3203	0.88305	0.94464	0.91444	0.91073
20	1.319799	0.88305	0.94464	0.91444	0.91073

20 modes were considered for analysis. The cumulative modal participating mass (both in X and Y) reaches to a value of 90% of the total seismic mass.

3.1.4. Modal Periods and Frequencies

Table 3.1.4.a Response Spectrum (Composite)

Mode Number	Period in seconds	Frequency in Cyc/sec	Circular Frequency in rad/sec	Eigen Value rad^2/sec^2
1	9.280204	0.10776	0.67705	0.4584
2	8.123352	0.1231	0.77347	0.59826
3	7.934987	0.12602	0.79183	0.627
4	6.905939	0.1448	0.90982	0.82778
5	6.552386	0.15262	0.95892	0.91952
6	5.933679	0.16853	1.0589	1.1213
7	5.88356	0.16997	1.0679	1.1405

8	5.341508	0.18721	1.1763	1.3837
9	3.060217	0.32677	2.0532	4.2156
10	2.916718	0.34285	2.1542	4.6406
11	2.489321	0.40172	2.5241	6.3709
12	2.417077	0.41372	2.5995	6.7574
13	2.413027	0.41442	2.6039	6.7801
14	2.404411	0.4159	2.6132	6.8288
15	1.960617	0.51004	3.2047	10.27
16	1.957717	0.5108	3.2094	10.301
17	1.67432	0.59726	3.7527	14.083
18	1.647212	0.60709	3.8144	14.55
19	1.3203	0.7574	4.7589	22.647
20	1.319799	0.75769	4.7607	22.664

Table 3.1.4.b Response Spectrum (RCC):

Mode Number	Period in seconds	Frequency in cyc/sec	Circular frequency in rad/sec	Eigen Value rad^2/sec^2

1	2.547691	0.39251	2.4662	6.0823
2	2.17747	0.45925	2.8855	8.3264
3	2.052827	0.48713	3.0607	9.3682
4	1.26328	0.79159	4.9737	24.738
5	0.96284	1.0386	6.5257	42.585
6	0.927038	1.0787	6.7777	45.937
7	0.842213	1.1873	7.4603	55.657
8	0.731998	1.3661	8.5836	73.678

Table 3.1.4.c Response Spectrum (Steel)

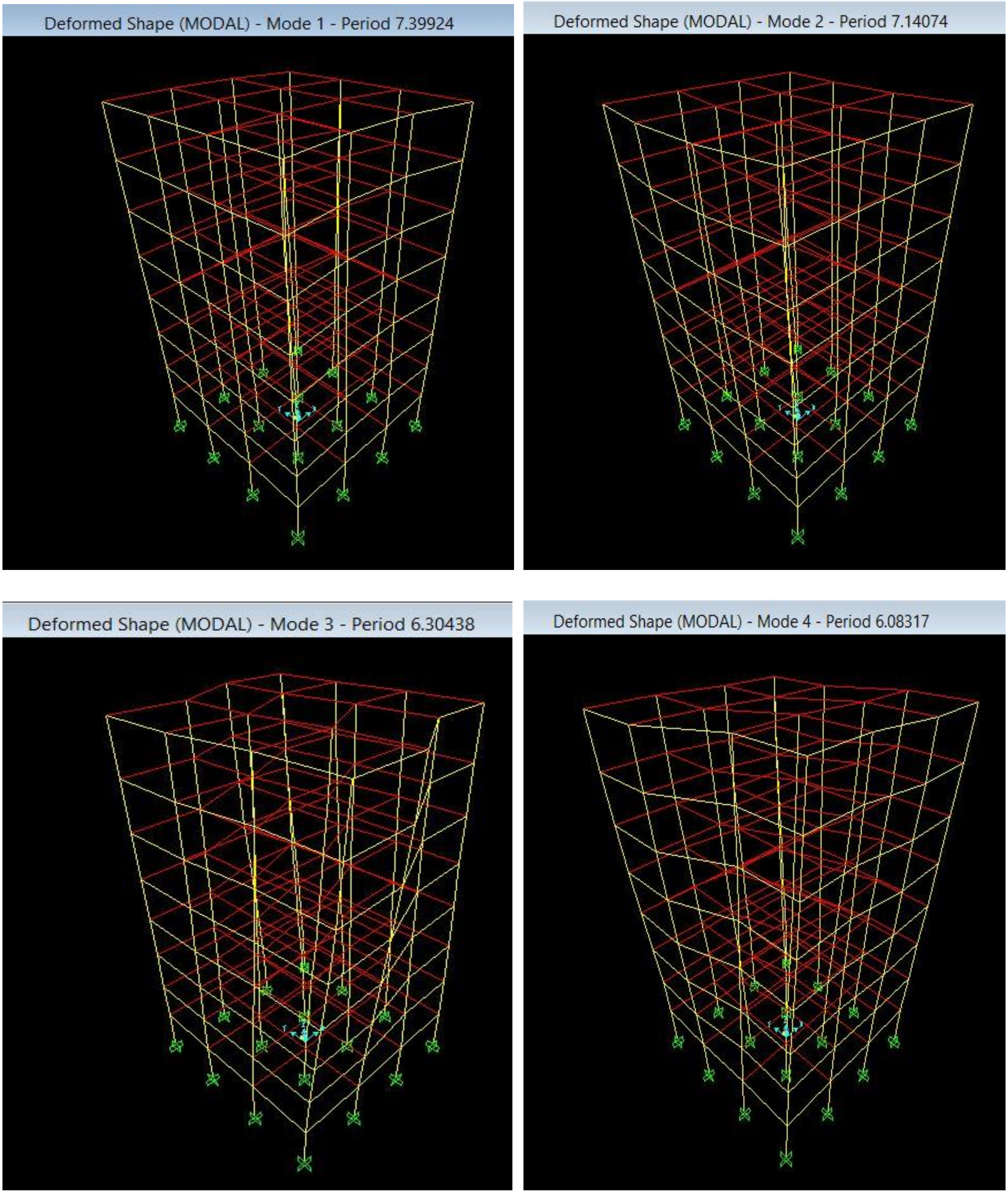
Mode Number	Period in sec	Frequency in Cyc/sec	Circular frequency rad/sec	Eigen value rad^2/sec^2
1	9.280204	0.10776	0.67705	0.4584
2	8.123352	0.1231	0.77347	0.59826
3	7.934987	0.12602	0.79183	0.627
4	6.905939	0.1448	0.90982	0.82778
5	6.552386	0.15262	0.95892	0.91952
6	5.933679	0.16853	1.0589	1.1213
7	5.88356	0.16997	1.0679	1.1405
8	5.341508	0.18721	1.1763	1.3837
9	3.060217	0.32677	2.0532	4.2156
10	2.916718	0.34285	2.1542	4.6406
11	2.489321	0.40172	2.5241	6.3709
12	2.417077	0.41372	2.5995	6.7574
13	2.413027	0.41442	2.6039	6.7801

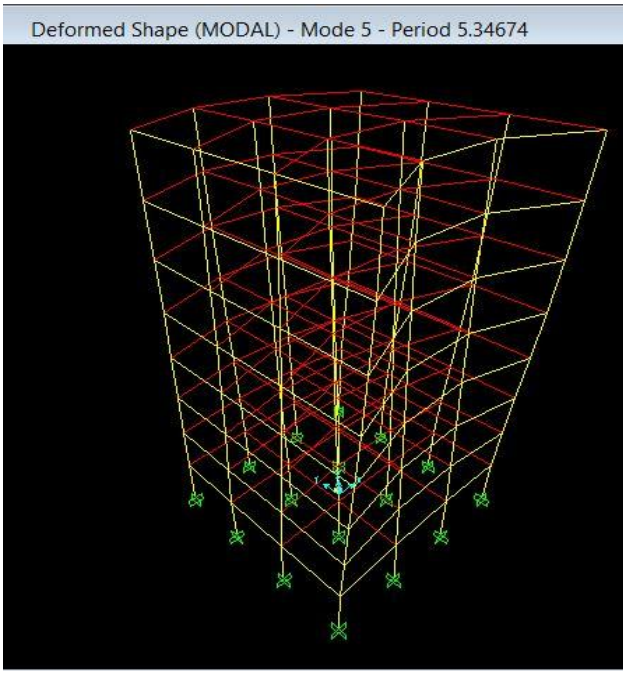
14	2.404411	0.4159	2.6132	6.8288
15	1.960617	0.51004	3.2047	10.27
16	1.957717	0.5108	3.2094	10.301
17	1.67432	0.59726	3.7527	14.083
18	1.647212	0.60709	3.8144	14.55
19	1.3203	0.7574	4.7589	22.647
20	1.319799	0.75769	4.7607	22.664

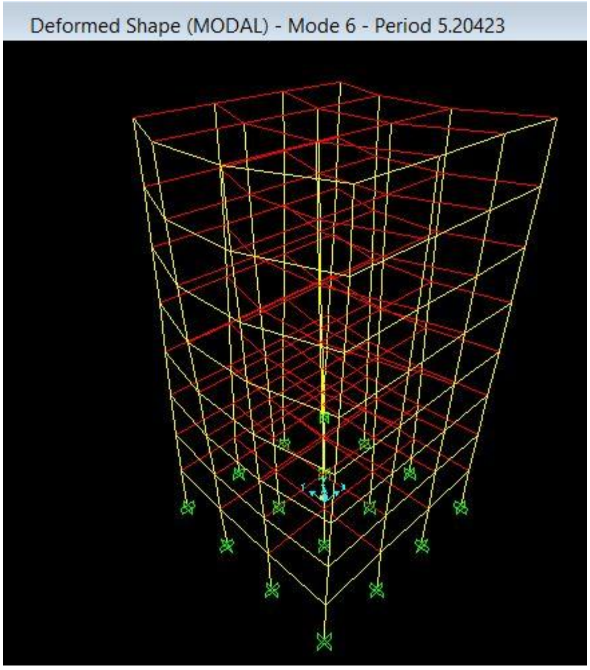
3.1.5 Mode Shapes:-

Response Spectrum (Composite)

Figure 3.1.5 The mode shapes for the first 6 modes for the composite building are:




Deformed Shape (MODAL) - Mode 5 - Period 5.34674


Deformed Shape (MODAL) - Mode 6 - Period 5.20423

3.2 Cost Comparison Analysis

Table 3.2.1 Composite Frame Structure

Material	Quantity Used	Rate of material	Amount
Structural Steel (kg)	320	Rs 42000/MT	Rs 13,440
Concrete used (m^3)	120	Rs 3000/m^3	Rs 3,60,000
Total Sum			Rs 3,73,440

Table 3.2.2 RCC Frame Strcuture

Material	Quantity Used	Rate of material	Amount
Reinforcing bar (kg)	500	Rs 41500/MT	Rs 20,750
Concrete used (m^3)	180	Rs 3000/m^3	Rs 5,40,000
Total Sum			Rs 5,60,750

Table 3.2.3 Steel Frame Structure

Material	Quantity Used	Rate of material	Amount
Structural Steel (kg)	2328	Rs 42000/ MT	Rs 97,860
Concrete Used (m^3)	100	Rs 3000/ m^3	Rs. 3,00,000
Total Sum			Rs. 3,97,000

Reduction Factor for Composite= Cost of Composite/Cost of RCC

= 373440/560750

= 0.67

Reduction Factor for Steel= Cost of Steel/Cost of RCC

= 3,97,000/560,750

= 0.72

Hence, reduction in cost of composite frame is 33% and steel frame is 27% compared with cost of RCC frame. This involves material cost only and doesn't include fabrication cost, transportation cost, labour cost etc.

CHAPTER-4
CONCLUSION

Conclusion:

- Storey drift in Equivalent Static Analysis in X-direction is more for Steel frame as compared to Composite and RCC frames.
- RCC frame has the lowest values of storey drift because of its high stiffness.
- The differences in storey drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column sections are different in both directions.
- Same storey drift patterns are obtained by using Response Spectrum method validating the results obtained by the Equivalent Static method.
- Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the steel and the composite frame. Base shear gets reduced by 40% for Composite frame and 45% for Steel frame in comparison to the RCC frame.
- Reduction in cost of Composite frame is 33% and Steel frame is 27% compared with cost of RCC frame. This involves material cost only and doesn’t include fabrication cost, transportation cost, labour cost etc.

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